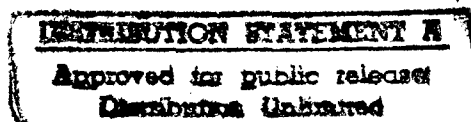# The Fox Project: Advanced Development of Systems Software

R&D Status Report
October 1 to December 31, 1996

School of Computer Science
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The long-term objectives of the Carnegie Mellon Fox Project are to improve the design and construction of systems software and to further the development of advanced programming languages. We use an advanced programming language in the design and construction of systems software, including operating systems, network protocols, and distributed systems. The language is based on Standard ML (SML), a modern functional programming language that provides polymorphism, first-class functions, exception handling, garbage collection, a parameterized module system, static typing, and a formal semantics. This Project involves several faculty members and spans a wide range of research areas, from (1) experimental development of systems software to (2) advanced compiler development to (3) language design.

1   Research Progress

For each of the three areas listed above, we report on the research accomplishments during the fourth calendar quarter of 1996, and the research objectives for the first quarter of 1997.

1.1   Experimental Development of Systems Software

Accomplishments (October-December):

- Completed the first suite of benchmark tests of FoxNet TCP.

- Improved the performance of FoxNet TCP by a factor of 10.

- Completed FoxNet ATM device layer.

Objectives (January-March):

- Complete the analysis and performance improvement for the FoxNet release 2.

- Add Kerberos security to the FoxNet implementation of the telnet protocol.

- Complete a more comprehensive version of IP v6 for the building block protocols.

- Complete FoxNet ATM interface (ML runtime and FoxNet integration).

- Implement an interpreter for the predicative version of the MIL (Middle Internal Language) to help with the development of the TIL2 compiler.

Noteworthy publications:

- Peter Lee, Edo Biagioni, Ken Cline, Chris Okasaki, and Chris Stone. Safe-for-Space Threads in Standard ML. Accepted at the *2nd ACM SIGPLAN Workshop on Continuations*, 1997.

- Kim B. Bruce, Leaf Petersen and Adrian Fiech. Subtyping is not a good 'Match' for object-oriented languages. To appear at the *Workshop on Object-Oriented Languages* (FOOL), January 18, 1997, in Paris, France, in affiliation with POPL '97.

1.2 Language Design

Accomplishments (October-December):

- Designed the extensions of the TIL compiler to the SML96 module system.

- Developed the concept of Proof-Carrying Code and demonstrated its effectiveness for safe kernel extensions.

- Developed a framework for proving the correctness of the proof representation used in Proof-Carrying Code.

Objectives (long-term):

- Develop a preliminary implementation of the "ML1996" core language; specifically, develop a type checker for the modules system.

Objectives (January-March):

- Complete a realistic implementation of refinement types for ML, structuring the implementation so that the modal system for staged computation can also be incorporated.

- Prove the correctness of the proof representation for Proof-Carrying Code.

Noteworthy publications:

- "Safe Kernel Extensions Without Run-Time Checking", by George Necula and Peter Lee, presented at OSDI'96 (*Second Usenix Symposium on Operating Systems Design and Implementation*, Seattle, October 28-31, 1996). This paper was awarded "Best Paper" by the conference Program Committee.

1.3 SML Compiler and System Development

Accomplishments (October-December):

- Completed the major design decisions for the TIL compiler.

- Designed a system for using C compiler (CMCC) back end for TIL code generation.

Objectives (January-March):

- Evaluate the performance of the TIL compiler on systems and networking code and compare it to the performance of SML/NJ.

- Extend the TIL compiler to compile the SML modules language.

- Continue development of TIL compiler.

- Design a new front end for the TIL compiler.

- Develop a framework for a "certifying compiler" that would produce Proof-Carrying Code from high-level programs.

2   Capital Equipment Purchases

- 1 800MB 2.5" LP SCSI-2 Disk Drive for the Mac Duo 280 Notebook Computer, $666.95

- 1 HPC-C-25 HP DeskJet 1600CM Printer, $1,756.00

- 1 PowerComputing PowerCenter 150, $2,604.45

- 1 2640FOE/IBM ThinkPad 560 P133 Notebook, 1 32MB Memory Upgrade, 1 3C562-TP 3COM PCMCIA Ether/Modum, 1 Spare Lithium Ion Battery, 1 Targus Universal Case, $5,236.00

- 1 NM-4/155 Network Module for ASX-200 MMSCC Switch 4 Ports, 155 Mbps, Multimode Fiber, SC Connectors, 1 SUPP-B-3 ForeMan Business Response, 1 PCA-200PCI Bus ATM Computer Interface, Mbps Multimode Fiber; SC Connector, 1 SUPP-B-3 ForeMan Business Response, 2 PCA-200E PCI Bus ATM Computer Interface, Drivers for DEC Alpha Machines, Connector, 2 SUPP-B-3 ForeMan Business Response, $5,451.60

3   Key Personnel Changes

- David Tarditi has completed his Ph.D. thesis and is now employed by Microsoft Corporation.

4   Noteworthy Meetings

- DARPA Quorum PI Meeting, Dallas, TX.

- IFIP WG2.8 Working Group of Functional Programming, Mohonk, NY. Presented "A type-Theoretic Account of Standard ML 1996".

- October 7-8: Dallas, DARPA/ITO PI meeting.

- October 28-November 2:   Operating System Design and Implementation Symposium, Seattle, WA.

- October 28-31:   Seattle, OSDI'96 conference to present a paper on Proof-Carrying Code.

- November 11: Philadelphia, lecture at UPenn on Proof-Carrying Code (paid by UPenn, not Fox Project).

- November 13-14:   DARPA/NSA Operating System Security Workshop, Alexandria, VA.

- December 10-11: Dallas, DARPA Quorum PI meeting.

5   Administrative Data

To be sent at a later date.